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A SIGNIFICANT DEVELOPMENT IN LIGHT WEIGHT ARCTIC AND WET WEATHER CLOTHING

by

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Presented at the Aerospace Medical Association Convention,
Chicago, Illinois, 26 April 1961.

Civilized man took over three hundred years to recognize that, physiologically, the Eskimo was in fact identical to the Caucasian race. He was viewed for the most part as a sub-human, living and eating like an animal, whereas he had developed the highest techniques of survival which permitted the continuation of life in his country. Some of the greatest tragedies in the Canadian Arctic and indeed, most of the hardships suffered by the early explorers from cold and malnutrition, were due entirely to this lack of identification. They wore, generally, heavy Navy clothing and leather boots which were completely inadequate and failed to realize that fresh meat was a sure prevention of that dread disease, scurvy. In terms of food, shelter, clothing and general techniques of living, it was not until 1913-1918 that Vilhjalmur Stefannson adopted in toto the Eskimo scheme of life during his journey of exploration in the Canadian Western Arctic. This is all the more amazing when reference is made to the early expeditions in lower Canada during the 16th century where we find a ready acceptance by the newcomers of Indian lore in all its facets.

In the early years after World War II it was very evident that the Armed Services and in particular, the Royal Canadian Air Force, had no clothing or footgear that would meet the rigid requirements of mid-winter Arctic climatic conditions and that little or no practical research had been done to produce the required insulation values. This resulted in personnel conducting operations in the far North either obtaining Eskimo clothing, or having to wear such a weight and bulk of standard clothing as to seriously reduce their efficiency. Materials up until this time, used in cold weather, had been produced on a hit-or-miss basis with the optimistic hope that it just might work.

It was with this in mind that the RCAF, in 1948, began a programme which was to be based on the known qualities of winter clothing, which had proved successful, in general use throughout the Arctic to

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measure scientifically these qualities where possible and to attempt to manufacture a more easily obtainable substitute which would be either equal or superior to the known material. The first objective was to develop a synthetic caribou skin, as this hide provided all the necessary insulation required by Eskimos or other residents of the Arctic. It might be pointed out here that man's work efficiency in cold weather is governed by weight, bulk and design of clothing rather than by low temperatures alone.

By the winter of 1949-50, the RCAF in concert with the Defence Research Chemical Laboratories had developed a nylon pile based on all the known physical measurements of caribou skin such as air permeability, weight, hair dimensions and population per sq. inch, tear strength and compressibility. User trials during two winters in the Arctic and continuous use at the RCAF Survival School until 1956, proved that this synthetic fabric had all the good qualities of caribou skin and was far superior in other respects. It would not shed, had a very high tear strength, could be washed and dried readily, and the durability was far above any material used for this purpose, known at that time. Another most desirable attribute was that, with the pile worn against the body, any excess moisture could be quickly evaporated by venting. It did have one undesirable feature caused by the neoprene used as a coating to control air permeability. Stiffening took place below -25 deg. F. and this made the garment somewhat uncomfortable to wear but did not subjectively reduce the insulation value. This fault was corrected in 1959 with the use of a new low temperature neoprene which would not stiffen down to -75 deg. F. The finished fabric has been turned over to the Department of Northern Affairs for use among the northern population. Although it is approximately the same weight as caribou skin, the RCAF did not adopt it due to its bulk and because of further research developments on other fabrics.

For many years a woven wool fabric had been used in the construction of protective socks and as a liner for medium weather parkas in the northern areas of Canada. This material is called Hudson's Bay Company's duffel cloth. However, there are several properties of this material that can be improved. It is difficult to sew, requiring reinforcemen at the seams; the nap wears off rapidly at pressure points and it is bulky, heavy and hard to dry. The development of synthetic duffel cloth was commenced in 1950 as a joint project between the RCAF Institute of Aviation medicine and the Defence Research Medical Laboratories, but it was not until 1959 that a heavy enough denier of nylon filament was produced commercially for this purpose. Even then, negative results were obtained in attempting to weave a suitable material. Finally, a knitted process was used which resulted in the production of a pure nylon fleece napped on both sides which is called, Flalon. Limited field trials have proven that this fabric has great promise. It is entirely acceptable as a lining material

when used in conjunction with certain fabrics, to be mentioned later in this paper. It is acceptable for use in duffel socks when worn in the vicinity of a station or settlement in the far North but is not designed at the present time for prolonged use under very cold conditions. Flalon is about one third the weight of wool duffel, absorbs no moisture, is easily washed and dried, has great durability and very strong seams can be sewn because of its knitted construction. It has an excellent storage life, being both moth and mold proof.

The generally recognized principle of extreme cold weather clothing has, in the past, been based on a direct relationship between the thickness of clothing and insulation value. Because of excretion of body moisture, clothing had to be vapour permeable and thus had a fairly high air permeability. This very property, which is a definite requirement, also forced the use of bulky and heavy fabrics to prevent the penetration of wind with the consequent heat loss. This arose from the fact that any such clothing must be ventilated in order to dissipate the body perspiration either through vapour permeability of the material or by direct means. It is not practical to avoid a build up of body moisture by direct venting because of the extreme heat loss occasioned at the same time. Therefore, any material used for clothing had to have sufficient permeability to allow vapour diffusion through the fabric at a high enough level to maintain dry garments. The so-called 'vapour barrier' clothing developed in the early 1950's, was doomed before it ever went out for trial because an impermeable barrier to both air and perspiration was set up in which the accepted principles of ventilation had been totally ignored.

Thus by 1958, no great progress had been made in perfecting a suitable fabric which would give complete air impermeability and a low vapour diffusion resistance because a reduction in permeability always increased resistance to diffusion. The same problem existed in developing a waterproof fabric for wet cold, as any of the known coatings used to accomplish this, i.e. rubber, latex, or neoprene, also created a complete barrier to moisture from the body and a consequent build-up which resulted in the garment becoming so wet as to be unserviceable.

A misconception that exists rather widely is that low temperature clothing should keep a person completely warm under all circumstances. Nothing could be farther from fact. Proper indoctrination should firmly fix in a person's mind that any exposure to the lower range of temperature is going to be uncomfortable and the degree of this will depend entirely on the ability to adjust to these conditions. Even Eskimo clothing made of caribou skin is not designed for the ultimate in warmth because the bulk required for a person inactive at extreme temperatures would effect his ability to perform any useful work. The ideal garment is one which will give the

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necessary insulation under a normal workload.

During the Spring of 1958 a routine visit was made to a commercial fabric manufacturer and a sample of a standard 2 oz. pure nylon taffeta, known as #2060, which had been treated with one of the polyurethanes, was examined. It appeared to be waterproof, had a fair tear strength but the vapour diffusion resistance was not known. Because of the success attained in the development of nylon pile clothing and the facility of being able to evaporate any excess moisture collected in the pile by venting, when it was worn next to the skin, a simple user trial was designed to try out the qualities of the #2060 together with a liner of Flalon. It was reasoned that if nylon pile could be dried on the body, the same should hold good of the Flalon as it is also a pure nylon, although a fleece.

A flight jacket was constructed of #2060 material (polyurethane treated) as the shell and lined with 1/4" Flalon which is approximately 10 1/2 oz. per sq. yd. This was worn for some time until warmer weather prevailed and appeared to be most acceptable. It was very light in weight and bulk, completely waterproof and at no time was any build-up of body moisture noted in either the liner or the inside of the shell fabric. A pair of overpants were now made up and lined with a very light synthetic doeskin. This combination was worn all of August, September and part of October aboard a tugboat in the Western Arctic area. Underclothing consisted of a viyella shirt (no undershirt) and only jockey shorts. Temperatures ranged from about 45 deg. F. to minus 12 deg. F. The subject was exposed for long periods to driving salt spray and occasional rain. At no time was there any penetration of moisture through the shell fabric or an accumulation of body moisture noted inside the garment and excellent insulation value was experienced. The jacket weighed 2 1/2 lbs. and the pants, 1 lb. 1 oz., or a total of 3 lbs. 9 ozs. It was suspected at the conclusion of the season's activities in the Arctic, that there must be some vapour diffusion through the #2060 fabric.

As the result of these observations, a joint project was agreed to between the Institute of Aviation Medicine and the Defence Research Medical Laboratories with the Departments of Transport and Northern Affairs being interested parties. The aim was to carry out further user trials on nylon fabrics treated with polyurethane, to measure the qualities of such fabrics by standard methods (tear strength of the warp and weft in lbs. thickness in inches, weight in oz/sq. yd., air permeability in cu.ft./sq.ft./min. at 0.5" water pressure differential and vapour diffusion resistance in cm.) and to produce a reference chart of each fabric so measured. It is the first time such a chart was projected in Canada where the relationship of vapour diffusion to all the other properties has been done

so extensively. During the 1958-59 winter a number of fabrics produced commercially were tested but the one with most promise appeared to be the #2060. This material, coated with polyurethane, proved to have an air permeability of less than 0.1 cu. ft./sq. ft/min. and a vapour diffusion resistance of 3.9 plus or minus 1.2 cm. A number of flying suits of this fabric (the pants and jackets zippered together at the back) were made up using Flalon as the interliner and a light nylon as a liner and sent out for user trials during the cold weather months. A limited amount of the same materials were also sent to Cambridge Bay, N.W.T. for use and report by the RCM Police, other residents and selected Eskimos. In the summer months of 1959, a further 500 yds. of treated #2060 and Flalon were distributed amongst the Eskimos along the whole Western Arctic coast. They were to manufacture their own clothing from both materials and also to use the Flalon for duffel socks in place of the Hudson's Bay Company's woolen duffel. A follow-up visit was planned for March in 1960 to evaluate the results and to compare the properties of the experimental fabrics with those commonly in use.

By the end of 1959, it appeared that an acceptable upper limit for vapour diffusion resistance in a clothing fabric would be approximately 5 cm. of still air as this gave an air permeability of less than 0.1 cu.ft./per sq.ft./min. It was considered that a major break-through had been accomplished in the production of this fabric. The #2060 nylon cloth coated with polyurethane was windproof, waterproof and yet came within the limits of vapour diffusion resistance. The programme was continued during the 1960 season.

Attempts were now made to control the polyurethane coating with regard to thickness so that air permeability and diffusion resistance could be varied. It was determined that this could be done with the #2060 fabric and also with another fabric known as #2131 having a weight of 3.9 oz. per sq. yd. The latter could be brought to a vapour diffusion resistance of 4.2 cm. which was important because of the extremely high tear strength in the material, approximately 28 lbs. #2060 has only about 4.48 lbs. and therefore is not suitable for work clothing. It was decided that further prototype clothing would be made from these two materials for a series of tests to be conducted during the 1960-61 winter months.

In the meantime further trials had been concluded with the #2060 flying clothing and a visit was made in March 1960 to Cambridge Bay to observe under what conditions the fabric and Flalon combination had been used by the local residents and Eskimos. The observers at Cambridge Bay found that standard parkas had been made by all concerned with some overpants and mitts. A number of children were also clothed in a similar

manner. The reactions of all concerned were enthusiastic and only two complaints were received. One was in regard to stretching of the Flalon when hung up to drip dry after washing. This was caused primarily by the material having been sewed in such a manner as to allow a vertical stretch rather than horizontal. The other was a complaint on the #2060 fabric being too susceptible to tearing when the wearer engaged in heavy work handling 45 gallon fuel drums. The general opinion obtained was that this combination of materials was more satisfactory for general wear around a northern settlement under all conditions than any other.

The flying clothing trials were carried out amongst Service personnel in two squadrons stationed at North Bay, Ont. The findings were based on a comparison of four sets of clothing made from different materials. The specific result obtained was that the #2060 fabric with the Flalon interliner was acceptable to aircrew as a flight garment. This observation was reported since it established a useable level of water vapour diffusion resistance in the flying environment.

The 1960-61 trials were much larger in scope and fully controlled. Wet cold tests were conducted at Summerside, Prince Edward Island, dry cold tests at Cold Lake, Alberta, and extreme dry cold trials at Resolute Bay, N.W.T. Another combination of fabrics was introduced to these tests. A neoprene coated #2060 shell was used with the Flalon interliner to produce a completely impermeable garment with a very high vapour diffusion resistance in excess of 70 cm. These neoprene coated garments were to establish end points on upper vapour diffusion. Parkas were also constructed of #2060 polyurethane treated fabric with the Flalon liner and trousers were made from the #2131 material mentioned in this report. Half the trousers were lined with 1/4" Flalon and half left unlined. Mitts were constructed from the same materials as the parkas but the palms and thumbs were faced with a new low temperature horsehide, known as Arctic Cream Glove. Velcro fastenings were used for closures at wrist and forearm. The results of these trials were most gratifying. The neoprene treated cloth, as expected, showed a severe sweating up on the inside. The polyurethane #2060 proved to be fully waterproof in wet cold and entirely acceptable for any dry cold temperatures in Canada when used for flying or working around a Station. The unlined #2131 pants were discarded for the lined ones because of chilling in the seat and knee areas. The latter proved to be a good work garment for outside use around the Station. The parka was also a success. The mitts were worn with and without woollen liners and were found to have sufficient range to provide the necessary insulation for all variations in working hand temperatures. These mitts, however, were not durable enough. For work mitts the #2131 material will be used in future trials.

Paralleling the clothing projects was one on cold weather footwear.

A boot called a mukluk (this is a misnomer since "mukluk" is the Eskimo term for a water boot used in the late Spring, Summer and early Fall) was developed for the Canadian Army in 1948-49. These boots were acceptable by the RCAF and have been in use during winter flying operations ever since. They proved to have all the insulation necessary in the coldest weather but were very bulky and with their complimentary foot insulation assembly weigh almost seven lbs. In 1958 it was decided to accept the cold weather insulation qualities of this boot as a criterion for the development of a more stream-lined and much lighter one. Flalon in a heavier weight was used for duffel socks. By 1960 this boot had been re-designed three times, each development showing more promise. Finally, a pair of boots were produced that weighed 3 lbs. 6 ozs. and the entire footgear weighed three lbs. less than those in use. This mukluk was put out for trial at various units and also at Resolute Bay. It has the same nylon fabric in the upper as the standard mukluk but a new low temperature cellular rubber in the sole and a zipper in the back for easy donning. It has proved to be most acceptable to aircrew and for use around a cold weather unit. It is not designed at the present time for long periods of inactivity during extreme temperatures. Development is continuing.

At the present time prototype cold weather outer clothing and footgear for the RCAF has been reduced in weight from 17 lbs. to 7 1/2 lbs. and flight clothing and footgear from 13 lbs. to 7 lbs. It is interesting to note that Eskimo winter clothing weighs about 6 1/2 lbs. for the outer assembly and boots.

While it is felt that considerable progress has been made on cold and wet weather clothing using these new materials, it is considered that this is only the beginning. Further research into design and development based on this experience should produce a vast improvement which will enable man's work output to be greatly increased during the cold weather months and his morale improved by the production of warm, light, waterproof clothing, adequate for all low temperature climatic conditions.

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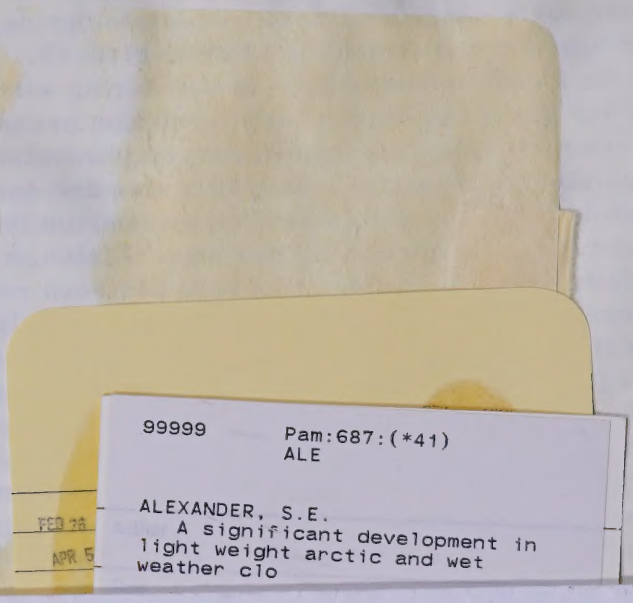
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